# Advisory Circular

# Advisory Circular Joint

**Subject:** AUTOMATIC PERFORMANCE RESERVE (APR) SYSTEMS

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**AC/ACJ No:** 25.904

**Initiated By:**

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**1. PURPOSE.** This Advisory Circular (AC) *[Advisory Circular Joint (ACJ)]* describes acceptable means, but not the only means, for showing compliance with the requirements of §25.904 and Appendix I of the Federal Aviation Regulations (FAR) *[of the Joint Airworthiness Requirements (JAR)]*.

**2. RELATED FAR *[JAR]* PARAGRAPHS.**
§ 25.107, 25.121,25.901, 25.904 and 25.1309

**3. APPLICABILITY.** The requirements of Section 25.904 apply to powerplant installations incorporating an engine power control system that automatically resets the power or thrust on the operating engine(s) when any engine fails.

An APR system is defined as a system that automatically resets thrust or power on the operating engines(s) when any engine fails during a takeoff/take-off or go-around. For the purpose of showing compliance with the requirements of §/JAR 25.904 and appendix I/Appendix I to part 25/JAR-25, the APR system comprises all elements of equipment necessary for the control and performance of each intended function, including the engine control system and all devices, both mechanical and electrical, that sense engine failure, transmit signals, actuate fuel controls or power levers of the operating engines(s) to achieve scheduled thrust or power changes, and furnish cockpit information on system operation.

Appendix I addresses APR for both take-off and for go-around. It is not intended to require that both capabilities be provided. For example, if APR for go-around is not provided, the requirements related specifically to go-around are not applicable.

**4. BACKGROUND.**
The requirements related to this subject were originally introduced through special conditions for ATTCS, Automatic Takeoff Thrust Control System, which were limited to take off operations. These special conditions were introduced into part 25 as requirements (25.904 and Appendix I) at Amendment 25-62 in 1987. After the development of Amendment 25-62, FADEC controlled engines became the norm for Transport Category airplanes and the APR

systems, when implemented, were integrated into the basic engine control package, not installed as a separate device. These controls offered reliable one-engine-inoperative (OEI) performance reserves and could reliably offer these reserves throughout the flight envelope. These systems were not envisioned at the time of the rule introduction (Amendment 25-62) and hence the rule was amended (Amendment 25-XX) to address these systems.

From the mid-1990's on, the majority of aircraft being certificated with an APR system were being certified with special conditions allowing for the use of APR for go-around. In Amendment 25-62, the FAA had specifically not allowed the use of APR in this scenario as it was deemed less safe, because a flight crew would have to memorize both OEI and all engines operating power sets for go-around. Later systems allowed the use of a common power setting procedure for the OEI and all-engines-operating scenarios, with adequate system reliability to address the different power or thrust for OEI situations (as per take-off). Amendment 25-XX includes requirements applicable to APR systems intended for use during a go-around.

## 5. SPECIFIC §25.904, Appendix I ASSESSMENT GUIDANCE.

### 1. Reliability:

FAR 25 Appendix I *[JAR-25 Appendix I]* specifies minimum reliability levels for these automatic systems. Compliance with these reliability levels for the APR system itself, engine failures in combination with an APR system failure and other failure conditions, such as indications, which can arise as a result of introducing an APR system must be shown to meet specific criteria in addition to FAR 25.901(c)/25.1309 *[JAR 25.901(c)/25.1309]*. The reliability assessment must include the applicable flight manual procedures (e.g. pre-flight, approach and/or daily checks), consider the mission length and exposure for potential dormant failures, and clearly define the assumptions used to define the critical time interval.

The term significant loss or reduction in thrust or power was defined in the pre-amble to this rule introduction, amendment 25-62. It states "'Significant loss or reduction in thrust or power" means an engine thrust loss that is more than two percent of the initially set total approved takeoff thrust for the airplane at existing ambient conditions.'

### 2. Indication:

Means to indicate that the system is available and functioning is traditionally done by dedicated indications of availability. An alternate means of indicating an APR system is armed and available, particularly with a system which is part of the basic engine control may be by indications of faults when the APR system or the engine control is not functioning (failed), has not passed it's built-in-test, or system integrity cannot be validated. System reliability between defined test or inspection intervals must be validated by a safety assessment. It is expected that some indication means exists on applying take-off power, either at take-off or go-around identifying that the system is available (or is not functioning properly). Should APR power be applied, either manually or automatically, this must be clearly identified to the flight crew by a means directly indicating APR power or thrust is being commanded.

APR systems must also provide means to clearly identify to the flight crew that operating limitations, noteably engine rotor speed(s) and gas temperture, will not be exceeded should APR power or thrust be required. This has been accomplished by:

- Defining & indicating 'soft' limits for normal take off which protect the 'hard'/ approved limits for maximum take off / APR thrust or power.
- Determining realtime the engine margins to the maximum approved limits and annunciate when a margin no longer exists (fully deteriorated).

The intent of this paragraph is to preclude latencies and ensure aircraft are not dispatched with beyond fully deteriorated engines.
The means selected must be validated.

Inhibit logic for aircraft with electronic crew annunciation systems should be considered in addressing crew workload scenarios during critical time intervals.

**3. Performance credit**

Performance credit for APR is limited to 111% of the normal take-off thrust or power set for take-off and go around. This limitation is intended to ensure a safe all-engines-operating takeoff. Without such a limitation, the all-engines-operating level of safety, which is set in the regulations by the one-engine-inoperative performance requirements, could be degraded.

**4. Allowable APR Uptrim**

Though performance credit is limited to 111% of initial power set, the actual engine power uptrim level may exceed that value. This allows some tolerance for initial power set and control uptrim power setting accuracy. Further it does allow controls to uptrim to maximum take-off power when using reduced power take-off's (ref:AC25-13). Engine and aircraft operating characteristics must be evaluated, as defined under the Thrust or Power Setting paragraphs, for the actual engine power uptrim level.

**5. Means to Verify before take-off**

The rule states 'The APR system must be designed to: ...(3) Provide a means to verify to the flightcrew before takeoff and before beginning an approach for landing, as applicable, that the APR system is in a condition to operate;'.
a) A means of compliance that has been accepted is that a verification means must be available should the flightcrew desire to check the system, but this check is not necessarily made mandatory. This means can be through a dedicated switch, pulling back one engine's power once the APR system is operative to confirm that APR is activated, or other approved means.
b) Further, the the system must indicate prior to take-off or approach for landing that it is functioning. Proper aircraft functioning with normal indications is an acceptable means, without necessarily requiring a dedicated APR armed indication, contingent upon all failures & significant faults being annunciated through cockpit messages. This should be substantiated by means of a system safety assessment. Confirmation of system health is by means of one or more of the following: cockpit annunciations, scheduled maintenance activities and/or aircraft flight manual checks.

**6. Deactivation Means**

The rule states that 'a means [must be provided] for the flight crew to deactivate the automatic function, unless it can be shown that such a means is unnecessary for safety.' This requirement is based on systems that may not be completely integrated into the rest of the engine control system, where it may be necessary from a safety standpoint to allow deactivation of this function. The rule recognizes that there may be circumstances where this means is not required or results in a decrease in safety. An example where disabling the automatic function would be unnecessary for safety would be an APR system fully integrated into the basic engine control such that should faults or failures that disable the APR function are equivalent to failures of the basic engine control. Such faults or failures would, however, require annunciation and /or fault accommodation. In certain extremely reliable designs which again must be part of the basic control, adding a dedicated means for deactivation might be shown to be a leading cause for APR failure during flight & /or lead to engine isolation / independence issues (one switch, both engines).

Systems that are not part of the basic engine control logic are required to have an independent dedicated means to deactivate the APR feature.

**7. Required Power or Thrust**

To maintain the same level of safety as airplanes without an APR system, it must be possible to manually increase or decrease the power or thrust up to the maximum power or thrust approved for the airplane. From a safety standpoint, there are situations other than engine failure where it may be necessary to use the maximum approved takeoff power or thrust (e.g., windshear recovery, terrain avoidance, collision avoidance). Also, in case the APR system fails to automatically reset thrust or power, the flightcrew must be able to manually reset it.

**8. Thrust or Power Terminology**

- The maximum approved takeoff thrust or power referenced in appendix I is the maximum takeoff thrust or power established for the airplane under part 25/JAR-25. It may not exceed the takeoff thrust rating limits established for the engine under part 33/JAR-33.
- The initial thrust or power that is set for takeoff with the APR system operative is generally referred to as normal takeoff thrust or power.
- The maximum available takeoff thrust or power is the thrust or power that the engine can achieve by the APR system or by manual means in accordance with aircraft flight manual procedures (vs the thrust or power that performance credit is based upon).
- The intended takeoff or go-around thrust or power is that which is anticipated to be achieved with the system working as per design. This value as a minimum is the value that aircraft performance is based upon, though may be greater.

**9. Engine Failure Recognition**

Engine failure recognition should be readily apparent to the flightcrew through the effect on airplane flight characteristics or aircraft / engine instruments. If it is not, a warning system independent of the APR system must be provided, i.e., the same engine failure indication source cannot be used to drive the APR system.

**10. Critical time interval** (CTI)

System reliability calculations are predicated on a determination of a "time at risk," i.e., a time period following the last verification that the system was serviceable up to the last point

in time where the failure of that system would have a significant detrimental effect on the safety of the aircraft.

For APR systems used on take-off, this time at risk ends shortly after take-off at a point where simultaneous failure of an engine and the APR uptrim would still permit the aircraft to reach 400 ft above the take-off surface at the same point had the APR been functional throughout (see App I25.2(b)). At this point, sufficient time would have elapsed for flightcrew action to reset thrust on the operating engine(s) to maintain the part 25/JAR-25 flight path requirements. For the take-off case, the critical time interval is significant in the system reliability calculations as it forms a relatively high percentage of the total time at risk. This is because most APR system components are verified as serviceable by the crew shortly before commencement of take-off. Hence specific criteria are defined within the rule (see App I25.2(b)(1)).

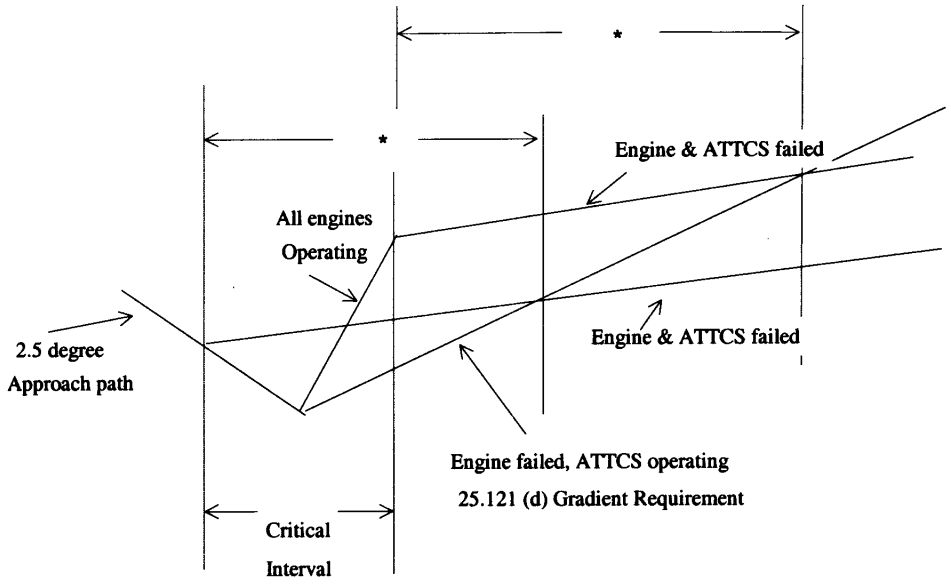
However, in the go-around scenario, the reliability calculations may be dominated by a much longer "time since last verification." For a number of critical components, this is the whole flight duration (typically an hour or more, depending on the aircraft). The few seconds added to this time by a calculated "critical time interval" for go-around at the end of the flight generally has a very minor effect on the overall time at risk and therefore on the calculated APR system reliability. Hence the CTI for go-around has been defined in the rule as a single value of 120 seconds. To cater for system designs where this conservative value would be unduly penalizing, the rule allows a shorter time interval to be used if justified by a rational analysis.

An accepted analysis that has been used on past aircraft certification programs is as follows:

**(a)** The critical time interval begins at a point on a 2.5 degree approach path from which, assuming a simultaneous engine and APR system failure, the resulting approach climb flight path intersects a flight path, originating at a later point on the same approach path, corresponding to the §/JAR 25.121(d) one-engine-inoperative approach climb gradient. The time interval from the point of simultaneous engine and APR system failure to the intersection of these flight paths must be no shorter than the time interval from $V_{EF}$ to a height of 400 feet above the takeoff/take-off surface during a takeoff/take-off (ref. §/JAR 25.111(c)(4).

**(b)** The critical time interval ends at the point on an all-engines-operating go-around flight path from which, assuming a simultaneous engine and APR failure, the resulting minimum approach climb flight path intersects a flight path corresponding to the §/JAR 25.121(d) one-engine-inoperative approach climb gradient. The all-engines-operating go-around flight path and the §/JAR 25.121(d) one-engine-inoperative approach climb gradient flight path originate from a common point on a 2.5 degree approach path. The time interval from the point of simultaneous engine and APR system failure to the intersection of these flight paths must be no shorter than the time interval from $V_{EF}$ to a height of 400 feet above the takeoff/take-off surface during a takeoff/take-off (ref. §/JAR 25.111(c)(4).

**(c)** The critical time interval must be determined at the altitude resulting in the longest critical time interval for which one-engine-inoperative approach climb performance data are presented in the Airplane Flight Manual.




* This time interval must be no shorter than the time interval from $V_{EF}$ to a height of 400 feet during takeoff.

Figure A